3. Of this total, 200,000 were collected in Connecticut and 300,000 were collected in Spain.
4. Bioassay tests were carried out by the method of B. C. Block [*J. Econ. Entomol.* **53**, 172 (1960)]. Field tests were carried out as described by J. M. Corliss ["Insects," *U.S. Dept. Agr. Yearbook Agr.* (GPO, Washington, D.C., 1952), p. 694]. The assistance of Mr. E. C. Paszek, U.S. Department of Agriculture, Nashua, N.H., in carrying out these tests is gratefully acknowledged.
5. E. von Rudloff, *J. Am. Oil Chemists' Soc.* **33**, 126 (1956); F. D. Gunstone and L. J. Morris, *J. Chem. Soc.* **1959**, 2127 (1959).
6. L. Crombie and A. G. Jacklin, *J. Chem. Soc.* **1955**, 1740 (1955).
7. W. R. Taylor and F. M. Strong, *J. Am. Chem. Soc.* **72**, 4263 (1950).
8. H. Lindlar, *Helv. Chim. Acta* **35**, 446 (1952).

6 August 1960

Expanding Shoals in Areas of Wave Refraction

Abstract. Shoals and spits may grow seaward, despite powerful refracted wave attack, where the wave energy level is too low to handle the supply of sand introduced by the littoral drift. Spits and shoals of this type have distinctive shapes. They may support ripple marks which do not parallel the crests of the waves which form them.

Wave refraction around a headland or point results in a concentration of wave energy, and hence a heightened level of activity. This fact is well known. The result is not, however, invariably erosion. Under certain conditions, concentrations of sand may occur, and be maintained, in areas of wave refraction. Such sand masses may appear as points, spits directed seaward, and near-shore shoals.

One requirement is that the coastal energy level be too low to handle the supply of sand (or other detritus) available. It may also be true that the unidirectional energy be essentially zero, as a result of cancellation of the littoral drift vectors.

Shoals, spits, and points of this type may appear on lagoonal shores, where wave energy is generally low, or on open, unprotected beaches. Each shoal commonly consists of several hummocks or faint swells, separated by gentle furrows, all arranged essentially parallel to the shore (see Fig. 1, *E*, for example). Such shoals may be rather large (that is, miles across; see Fig. 1, *A* and *B*) or small (tens or hundreds of feet across; Fig. 1, *C* and *D*).

The examples reported here occur along a coast of zero to moderate energy. This classification is based on a scale on which an average breaker height of 1 to 10 cm indicates low energy, 10 to 50 cm, moderate energy, and more than 50 cm, high energy. The average breaker at Cape San Blas, Fla. (Fig. 1, *A*), is about 13 cm (*1*). The energy level decreases from there toward the east. At Keaton Beach (Fig. 1, *D*), no long-term average is available, but breakers commonly do not form along the beach at all, and much of the time only small ripples, millimeters high, disturb the surface near the water's edge.

The breaker height at Cape San Blas indicates an energy level sufficient to handle (in terms of net littoral drift, past a given point) only about 2.5×10^4 m^3 of sand per year. Over the years, the Apalachicola (that is, Chattahoochee) River has delivered a greater load than that. Hence the large shoal areas at Cape San Blas and Cape St. George (Fig. 1, *B*) are related to the moderate level of coastal energy, coupled with the relatively large available supply of beach and near-shore sand.

Near Bald Point (Fig. 1, *C*) and Keaton Beach the annual accretion of sand is almost negligible, but the energy level is also very low. The small supply of sand is therefore piled into similar spit-and-shoal areas. These smaller features are in no sense beach cusps, although beach cusps commonly form in the same areas. (Beach cusps do not extend, below water, as shoals.)

Fair weather wave refraction patterns, on the smaller shoals, are quite clear (Fig. 1, *F*), and indicate a piling up of sand in these localities. During storms some of this sand is probably moved seaward, only to be worked landward again during the next period of long-term, essentially calm weather. Refraction of the waves produces two apparently dissociated wave sets, which cross each other at acute angles. The ripple marks produced by these two sets are more-or-less regular in general plan, but parallel neither wave set. Instead, they bisect the acute angle between the two sets, and approach an angle of roughly 45° with either set. Ripple marks of this type seem to be characteristic of the smaller shoals, where the water is very shallow (that is, less than 10 ft). Ripple marks on the larger shoals, which occur in deeper water, are of the more conventional types.

In some instances large shoal areas may result from an abundance of river sediment (as in Fig. 1); in others, a similar pattern may be due to decreasing energy, in the down drift direction (for example, the shoals off of Cape Hatteras, Cape Lookout, and Cape Fear, N.C., where the average breaker heights are about 85 cm, 75 cm, and perhaps 55 cm, respectively).

Sand concentrations of the variety described here are indications that the locality studied either now has, or recently has had, a supply of sand greater than that required by the prevailing wave energy level. The beach at such points must be, in general, either stable in position or prograding. This inter-

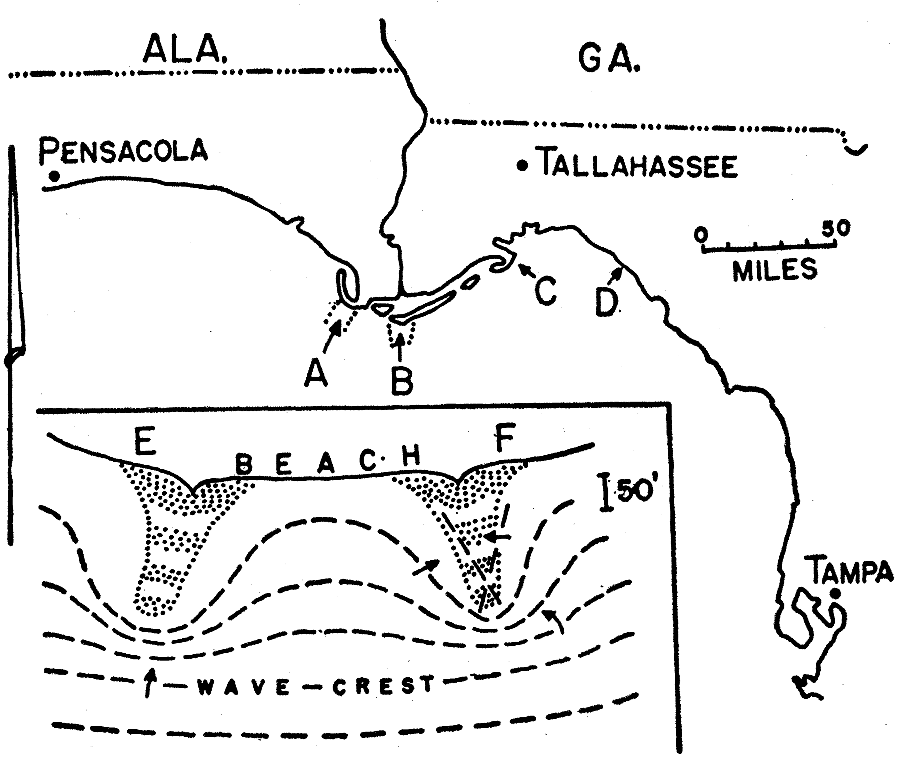

Fig. 1. Map of the Apalachicola River delta and adjacent parts of Florida, showing the location of shoals where available littoral materials are excessive, in the light of the current wave energy levels. Large shoals occur at Cape San Blas (*A*) and Cape St. George (*B*); many small shoals, closely spaced, occur at *C* and *D*. Inset: diagram showing details of two typical small shoals, with wave refraction patterns, such as those near *C*.

pretation should be made, regardless of temporary effects such as those produced by a hurricane.

There is, however, no indication as to the absolute amount of sand available for littoral drift, nor for the absolute energy level. Examples of these "overload" shoals can be seen along areas of essentially zero energy, low energy, moderate energy, and high energy. In each case it is necessary only that the supply of sand along the beach exceed the amount which would normally be moved, in view of the wave energy level.

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Reference

1. J. R. Helle, *Beach Erosion Board TM-108* (1958).

14 March 1960

Delayed Visual Feedback and Behavior

Abstract. By means of video-tape recording the visual presentation of a person's behavior, as he carries out some task, can be delayed in such a way that the individual sees what he is doing a short time after he has done it. The effects of this delay of visual feedback on a variety of simple visual-motor tasks are found to be both marked and deleterious, and in some respects similar to the effects of delayed auditory feedback on speech and motor tasks.

In the same way that the sound of a subject's voice can be stored momentarily on magnetic tape and played back during the course of speech (*1*), it is possible, through the use of newly developed video-tape recording and reproducing equipment, to store and play back the visual representation of a subject's performance field in such a way that the subject observes a televised display of his behavior shortly after the behavior has occurred. In this report we describe the results of some preliminary observations concerning the effects of such visual delay on a sample of visual-motor tasks.

The RCA laboratory magnetic tape video recording and reproducing system was used to produce delayed vision (*2*). The subject sat in front of a television monitor (21-in. screen) which received the output of a second playback unit. A delay of approximately 520 msec was provided. In order to prevent the subject from seeing the task area directly, a pair of special goggles was used. An RCA miniature television camera was located at eye level and next to the subject's head to minimize angular distortion of the televised performance field. Magnification of the performance field was approximately 1.5.

The subject carried out various tasks on the electronic handwriting analyzer, a device described by Smith and Bloom (*3*), which permits the measurement of both manipulative and travel components of writing or similar motions. The subject observed on the television screen a portion of the writing surface of this device, together with his hand with the pencil in it and a part of his forearm.

The nine different tasks listed in Table 1 were performed by two subjects under three conditions of observation; television-delay, television-no delay, normal (ordinary observation). Tasks, as well as sequences of words and syllables, were randomly assigned to each subject. Comparisons among the three conditions suffer from the lack of control for practice, in that the observations with delay were obtained 2 weeks prior to those obtained under the no-delay conditions, but in view of the magnitude and nature of the observed differences and the nature of the tasks themselves, not much significance is attached to the possible effects of practice from condition to condition. Instructions in all three cases were to perform the task as accurately and as rapidly as possibile (and as neatly as possible in the case of writing tasks).

The first thing to be said about the effect on behavior of delayed visual feedback as revealed in these observations is that performance becomes inordinately difficult and frustrating. It is nearly impossible to perform the simplest of tasks, such as placing a dot in the center of a circle, with any reasonable degree of accuracy. Any localizing movement, in fact, demands great effort, and little accuracy is obtained. What normally would be fast, smooth, placing motions become erratic and oscillatory movements which assume a characteristic jerkiness. Handwriting, even of very familiar material, becomes severely degraded and in some cases completely illegible. In Fig. 1 are reproduced some of the original records showing samples of star tracings, drawings of simple geometrical figures, maze tracings, and handwriting. Specimens from the records of the two no-delay conditions are given for purposes of comparison.

An error analysis of the writing material reveals that, in addition to the obvious degradation of legibility, particular kinds of errors occur. The most frequent kind of error in a total of 64 errors was letter duplication (40.6 percent), examples of which can be seen in Fig. 1, *D* and *E*. The predominance of this type of error parallels the findings of the Bergeijk and David study (*4*) and agrees with the results on articulatory errors found in delayed auditory feedback.

most frequent kind of error found in our observations was error of insertion —that is, the occurrence within a word of letters or part letters which did not belong there (26.6 percent). There were a few errors of omission (7.8 percent), one error of substitution, and a variety of miscellaneous errors (23.4 percent). The relatively frequent occurrence of errors of duplication and insertion might be considered "graphic stammering and stuttering," analogous to the articulatory effects in speech due to delayed auditory feedback.

Evaluation of the accuracy of performance of the nonwriting tasks shows more dramatically the effects of delayed vision. In the star- and maze-tracing tasks some of the records were so bad that they were literally unscorable. The star record in Fig. 1 is the best example of this extreme degree of degraded performance. There was, however, an obvious improvement in these two tasks over the few trials performed by each subject. An interesting question for future investigation is the degree of improvement obtainable in such tasks with extended practice.

In addition to the low quality and low accuracy of performance produced by the delayed visual feedback, very marked effects on temporal characteristics of performance were found. Table 1 summarizes the time data for the two

Table 1. Manipulation or contact time for the various visual-motor tasks for each subject under the three conditions of observation. All values are means in seconds. Data on two tasks under the television-delay condition were not obtained for subject B.

Subject	Time (sec)		
	TV delay	TV no-delay	Normal
	Writing letters of alphabet		
A	2.0	0.6	0.6
B	1.2	0.7	0.5
	Star-tracing		
A	86.2	13.8	5.9
B	49.6	16.0	6.3
	Drawing 3 geometric figures		
A	6.1	3.5	3.5
B	5.0	6.4	4.7
	Writing 4-letter nonsense syllables		
A	4.8	4.1	2.0
B	6.4	2.4	1.9
	Writing 4-letter words		
A	4.3	1.7	1.5
B		2.6	1.6
	Maze-tracing		
A	102.8	18.0	7.2
B	107.6	23.9	7.6
	Writing Bergeijk-David words		
A	5.9	2.5	2.2
B	5.5	3.1	2.4
	Writing 3-letter nonsense syllables		
A	5.1	1.7	1.4
B		2.2	1.6
	Placing dots in 6 circles		
A	27.8	2.8	2.5
B	12.7	4.0	1.7